1

100 OVERVIEW

Purpose

The 90.1 Code, which this manual explains, is a set of requirements for the energy efficient design of commercial buildings. The 90.1 Code is technically equivalent to ASHRAE[1]/IES[2] Standard 90.1-1989. The principal difference is that the 90.1 Code is organized like a building code and written in code language.

The 90.1 Code was approved by the ASHRAE and IESNA boards in 1993 and is intended to promote the application of cost-effective design practices and technologies that minimize energy consumption without sacrificing either the comfort or productivity of the occupants. In addition, the 1995 CABO MEC[3] adopts the 90.1 Code by reference as it applies to commercial buildings. The Energy Policy Act of 1992 (EPAct 92) requires state and local governments to update their commercial building energy efficiency codes to be at least as stringent as ASHRAE Standard 90.1-1989. To meet this requirement, many states are expected to adopt the 90.1 Code.

The purpose of this Code Compliance Manual is to explain the requirements of the 90.1 Code and recommend procedures and documentation on how to comply with, implement, and enforce the code. The manual is targeted to a diverse audience and, therefore, contains information that may or may not be needed by everyone.

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[1] American Society of Heating, Refrigerating and Air-Conditioning Engineers, Inc.
[2] Illuminating Engineering Society of North America
[3] Council of American Building Officials Model Energy Code

The following chart highlights information in the manual that may be of specific interest to building industry professionals, contractors, plans examiners, and field inspectors.

Table 100A Information Contained in this Manual

	Locations in the Manual	Design Professionals	Contractors	Plans Examiners	Field Inspectors
Figures and tables to help understand the scope and requirements of the code	All Chapters	•	•		
Example Questions and Answers for situations likely to be encountered	Chapters 100, 401, 402, 403, 404	•	•		
Compliance forms, worksheets, and checklists filled out for a real case study building	Chapters 401, 402, 403, 404	•		•	•
Introduction to LTGSTD and ENVSTD compliance tools	Chapters 401 and 402	•			
Responsibilities of: Permit Applicant Plans Examiner Field Inspector	Chapters 401, 402, 403, 404	•		•	•
How to verify items and materials in the field	Chapters 401, 402, 403, 404	•			•
Review of enforcement issues	Chapters 401, 402, 403, 404			•	•
Reference sections to cover special topics related to technical chapters	Chapters 401, 402, 403, 404	•	•		
Appendices with reference information	Appendix	•			
Index	Index	•	•	•	•

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Scope and Application

The 90.1 Code is broad in its application. In general, the requirements address the design of all building systems that affect the visual and thermal comfort of the occupants, including:

- Lighting systems and controls
- Wall, roof, and floor insulation
- Windows and skylights
- Cooling equipment (air conditioners, chillers, and cooling towers)
- Heating equipment (boilers, furnaces, and heat pumps)
- Pumps, piping, and liquid circulation systems
- Supply and return fans
- Service hot water systems (kitchens and lavatories)
- Permanent electric motors (e.g., elevators and escalators)

It does not address the energy used by office equipment such as personal computers, copy machines, printers, fax machines, and coffee makers. Nor does it address kitchen equipment in restaurants, commercial kitchens, and cafeterias, although water heating, lighting, and HVAC energy uses in these types of spaces are covered.

Building Types Covered. The 90.1 Code applies to *new* commercial and high-rise residential buildings. High-rise in this context is defined to include buildings with four or more habitable stories. The 90.1 Code does not apply to low-rise residential buildings such as single family homes, duplexes, and garden apartments. However, these building types are generally covered by a comparable standard based on the Model Energy Code[4].

Exempt Buildings. The 90.1 Code specifically exempts buildings that are intended primarily for manufacturing, commercial, or industrial processing. However, if only a portion of a building is used for processing, the rest of the building (the administrative offices, for instance) is still covered by the 90.1 Code.

Very small buildings with less than 100 ft^2 of gross floor area are exempt. This exemption applies to guard stations, photo processing stands in the parking lot of shopping malls, kiosks, flower stands, and other small buildings.

The third and final general exemption is for buildings that use very little energy. The threshold is 3.5 Btu/(h-ft^2) of gross floor area which is equal to about 1.0 W/ft^2 of electric energy. In order to qualify for this exemption, the total peak power for space conditioning, service water heating, and lighting must be less than the threshold. This exemption generally applies only to buildings in mild to moderate

[4] The Energy Policy Act of 1992, which requires that states update their commercial energy code to be at least as stringent as ASHRAE Standard 90.1-1989, also requires states to review their residential energy code and consider making it as stringent as the 1992 Council of American Building Officials (CABO) Model Energy Code (MEC).

climates that have no heating or cooling system such as warehouses and storage facilities. Some semi-heated buildings may also qualify for this exemption.

Application to Existing Buildings. The 90.1 Code is silent about its application to additions, renovations, repairs, replacements, and/or remodeling. Adopting jurisdictions may expand the scope of the 90.1 Code to apply to these cases. One cost effective example would be to expand the scope of the lighting requirements to completely new lighting systems installed in existing buildings. Please review the code adopted for your area to verify how the requirements apply to existing buildings.

Table 100B Examples of Building Types Covered by the 90.1 Code

Airports	Laboratories
Banks	Libraries
Barber shops and beauty parlors	Museums and galleries
Bowling alleys	Nursing homes
Churches, synagogues, and chapels	Offices
Convention centers	Police and fire houses
Dormitories (more than three stories)	Restaurants
Exhibit halls	Retail stores
Gymnasiums	Schools
Health clubs	Shopping malls
High-rise residential	Shops (non-industrial)
Hospitals	Sporting arenas
Hotels and motels	Theatres and auditoriums
Indoor sporting facilities	Warehouses and storage facilities

Note: This table includes only *examples* of building types covered by the 90.1 Code. It is not intended to be an exhaustive list. Other building types may be covered, even though they are not listed.

Example 100A Code Application for Food Processing Plant

Q A commercial food processing plant has 70,000 ft^2 of space where vegetables are cooked, canned, labeled, boxed, and shipped. The building has an additional 20,000 ft^2 of administrative space. Is the entire facility exempt from the code because it is intended primarily for commercial processing?

A Only the 70,000 ft^2 of commercial processing space is exempt because the primary use of energy is not for comfort conditioning. The 90.1 Code still applies to the 20,000 ft^2 of administrative space.

The exemption does not mean, however, that there are no opportunities for energy efficiency in the manufacturing portion of the building. For instance, the designer should select efficient lighting equipment and design it to provide enough, but not too much, illumination.

Example 100B Code Application for Information Kiosk

Q The City of St. Louis is building a small information kiosk in the downtown area. The kiosk is heated and cooled by a through-the-wall heat pump. Illumination is provided by small skylights and recessed compact fluorescent luminaires. The entire building measures 8 ft by 11 ft. How does the 90.1 Code apply to small structures such as this?

A The building is exempt because it is smaller than 100 ft^2.

Example 100C Code Application for Parking Garage

Q An office tower has a four-story parking garage below grade. The tower and the garage are on the same electric and gas service. The only energy used by the garage is for lighting and exhaust fans and the peak electric power is 0.9 W/ft^2. Is the garage portion of the building exempt from the 90.1 Code because peak power is less than 3.5 $Btu/(h\text{-}ft^2)$ or 1.0 W/ft^2

A No. The fan motors must meet the efficiency requirements and the lighting system serving the garage must meet the lighting requirements. While the garage is separated from the tower by a concrete floor that provides the necessary fire separation, it is not on a separate electric or gas service. The word "separated" means to have a separate electric and/or gas service.

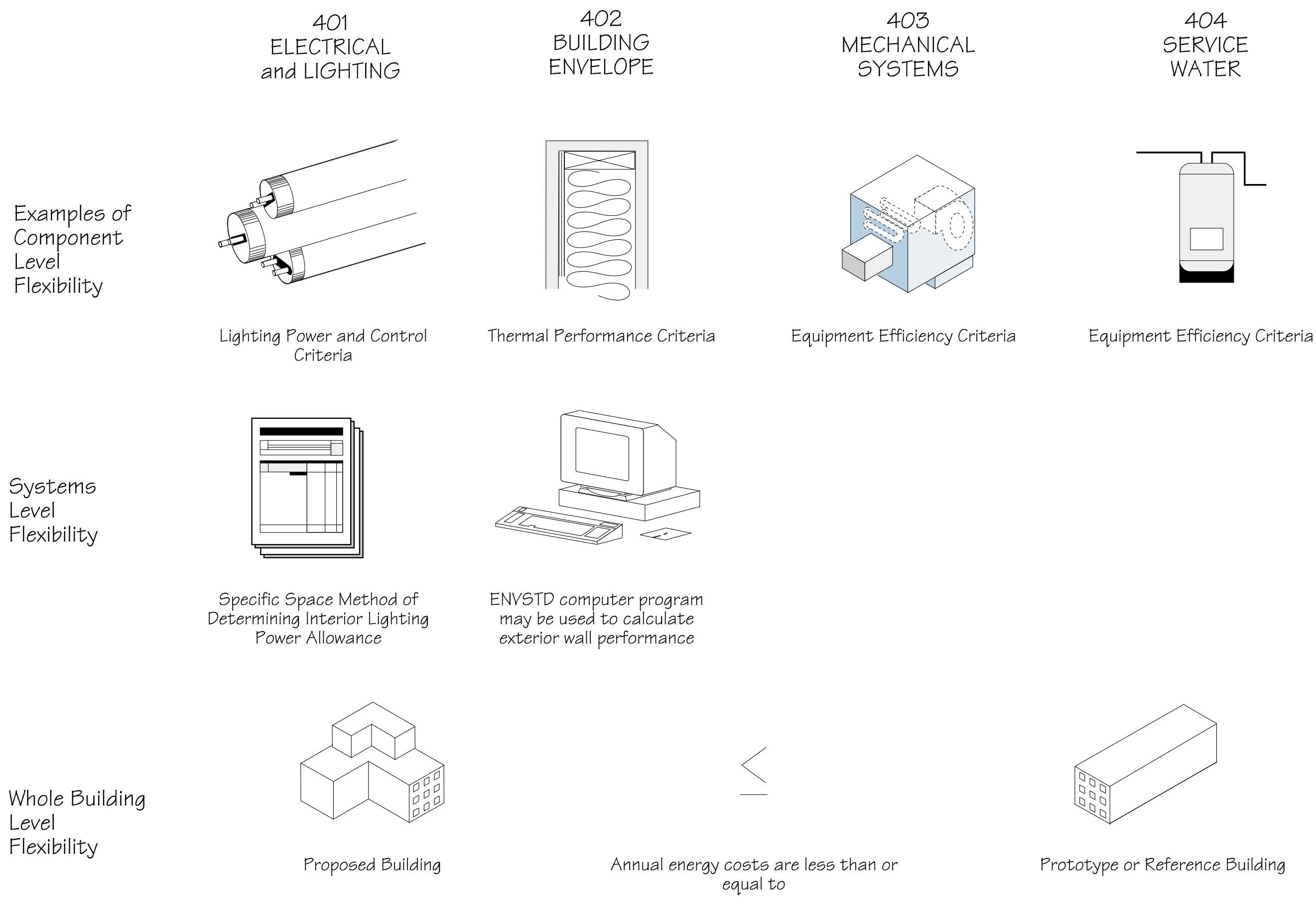
Compliance Options and Design Flexibility

Since the 90.1 Code applies to such a wide variety of building types (see Table 100A), it is essential that the code be flexible in its application. The goal of the 90.1 Code is to achieve energy efficient building performance. When possible, this goal is achieved without requiring specific measures or products. Flexibility is provided at the components level, the systems level, and at the whole building level. (See Figure 100A).

COMPONENT LEVEL FLEXIBILITY

Flexibility is achieved at the *component level* by specifying criteria in terms of overall component performance. The criterion for the roof component, for instance, is stated in terms of the overall U-factor. Any construction assembly or method may be used as long as its U-factor meets the overall criteria. For the building envelope, additional flexibility is offered through area-weighted averages. For example, one portion of the roof can fail to meet the criteria if it is offset by another portion(s) that exceeds the criteria, resulting in an area-weighted average U-factor that is less than the criteria.

Figure 100A Design Flexibility Provided by the 90.1 Code



Lighting control requirements can be satisfied with multiple switches, occupant sensors, time clocks, or dimmers but must be satisfied on a space-by-space basis. Lighting power requirements can be satisfied by any combination of equipment as long as the total power is less than the criteria. HVAC equipment and water heaters can be manufactured in a variety of ways as long as they meet the overall criteria of energy efficiency, e.g. energy efficiency ratio (EER). It is not acceptable, however, to average equipment efficiencies.

SYSTEMS LEVEL FLEXIBILITY

Additional flexibility is achieved at the *systems level* for interior lighting power and for exterior walls. The interior lighting power allowance can be determined by the building space or specific space method. The building space method is simple, straightforward and is easy to apply to the majority of cases. The specific space method is available when building interiors have more unusual lighting needs. With this method, the designer establishes a separate allowance for individual lighting tasks or for each specific space within the building.

For exterior walls, the 90.1 Code has prescriptive tables that give combinations of window area, window U-factor, shading coefficient opaque wall U-factor, etc. that satisfy the requirements. This is the simplest way to meet the exterior wall criteria. If the prescriptive tables do not offer enough flexibility, an alternative method may be used that allows consideration of window area and orientation; thermal mass; insulation position (on the inside or outside of the wall); daylighting; and internal gains from lights, equipment, and people. This method for exterior walls is implemented through a computer program called ENVSTD. Version 2.1 of this program should be used with the July 1993 version of the 90.1 Code. Copies are available from ASHRAE[5].

WHOLE BUILDING LEVEL FLEXIBILITY

The greatest flexibility is achieved at the *whole building level.* Section 102 of the 90.1 Code permits the use of the energy cost budget method to evaluate the performance of a building in its entirety. As long as the estimated annual energy cost of the proposed design is less than or equal to the estimated annual energy cost of the budget building, the proposed design meets the 90.1 Code. More information on the energy cost budget method is provided in Appendix A. When this method is used, the calculations must be certified by a registered architect or engineer. To use the energy cost budget method, you will need a copy of Standard 90.1, available from ASHRAE (see above), and an energy analysis computer program appropriate for use with the 90.1 Code.

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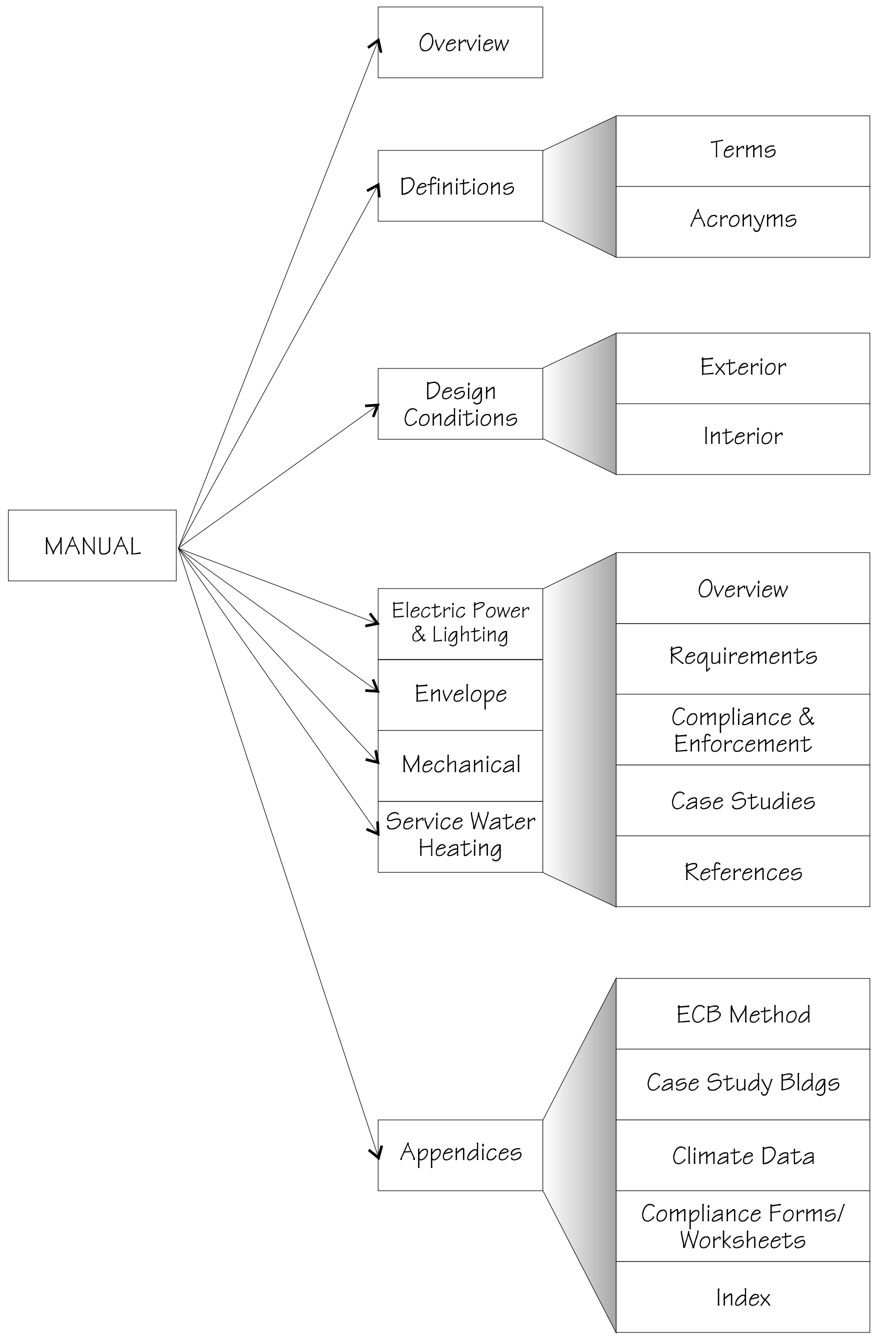
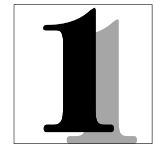
5 American Society of Heating, Refrigerating, and Air-Conditioning Engineers, 1791 Tullie Circle, N.E., Atlanta, GA 30329

Organization of the Manual

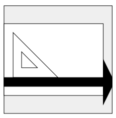
Figure 100B Organization of the Manual



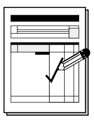


The organization of this manual follows the 90.1 Code. In addition, each of the technical chapters is divided into the following sections:

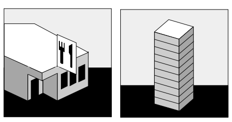
An overview explains the scope and application of the requirements, outlines the compliance options when they exist, and, in the HVAC chapter, provides a cross reference to system type. The overview reviews principles and rationale underlying the requirements, and explains why the particular building system is important to energy efficiency. A filled out and annotated Summary Form for the appropriate technical chapter is introduced as the organizing element for the remaining sections of the chapter.



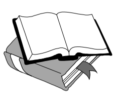
The second section covers each of the requirements in the order that they appear in the code and on the Summary Form, but in greater depth and with supporting material such as figures, tables, and examples.



The third section covers compliance and enforcement including a general description on how to use the forms and worksheets that are provided in Appendix D. This section outlines the responsibilities of the permit applicant, plans examiner, and field inspector. It also reviews enforcement issues, and provides suggestions on how to verify certain items and materials at the project site.



The fourth section contains case studies of the compliance and enforcement process. Complete compliance documentation (filled out Summary Forms and Worksheets, where appropriate) is provided for the case study office building in Appendix B. A description of a restaurant case study is provided for use as a class exercise.



Additional reference sections may be included to cover special topics such as how to calculate U-factors, how to determine lighting power, and other topics directly related to the technical chapter.

A technical appendix provides details of the case study buildings, climate data, and other reference information. This is followed by an index to topics and terms.

1

The 90.1 Code

UPDATES AND MODIFICATIONS TO THE 90.1 CODE

This Code Compliance Manual is consistent with the 90.1 Code as approved by the ASHRAE and IESNA boards in July of 1993. The reader should be aware that the code adopted in your jurisdiction may be slightly different from the July 1993 90.1 Code, and therefore, some of the material in this manual may not be consistent with your code. These inconsistencies may result for two basic reasons.

- Since the writing of this manual, the 90.1 Code may have been changed by the ASHRAE and IESNA boards and this manual may have not yet been updated. A number of addenda to ASHRAE/IES Standard 90.1, which underlie the 90.1 Code, were pending at the time of this writing. When these addenda are approved, it is expected that the 90.1 Code will be updated.
- Adopting jurisdictions may have modified the 90.1 Code in order to suit local economic, political, or weather conditions. Corresponding changes may not have been made to the Code Compliance Manual.

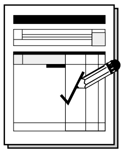
DISTINCTIONS BETWEEN ASHRAE STANDARD 90.1 AND THE 90.1 CODE

The 90.1 Code is technically consistent with ASHRAE/IES Standard 90.1-1989. The major differences are:

- Advice and recommendations contained in Standard 90.1-1989 are eliminated. Only "shall" requirements are included.
- Standard 90.1 is organized in 14 sections, while the 90.1 Code is organized in five chapters in a manner more consistent with other codes. The technical requirements are all contained in Chapter 4.
- The details of the energy cost budget method are not included in the 90.1 Code, rather a reference is made to Standard 90.1-1989 (see Section 102 of the 90.1 Code).
- Standard 90.1 has 38 prescriptive criteria tables for the building envelope. Each table represents a group of one to 17 cities. The 90.1 Code eliminates these groupings and provides separate criteria for 234 cities.
- The details of the systems performance method for the building envelope (ENVSTD) are excluded from the 90.1 Code. Instead, the systems performance method is included by reference to ASHRAE Standard 90.1.

The Compliance and Enforcement Process

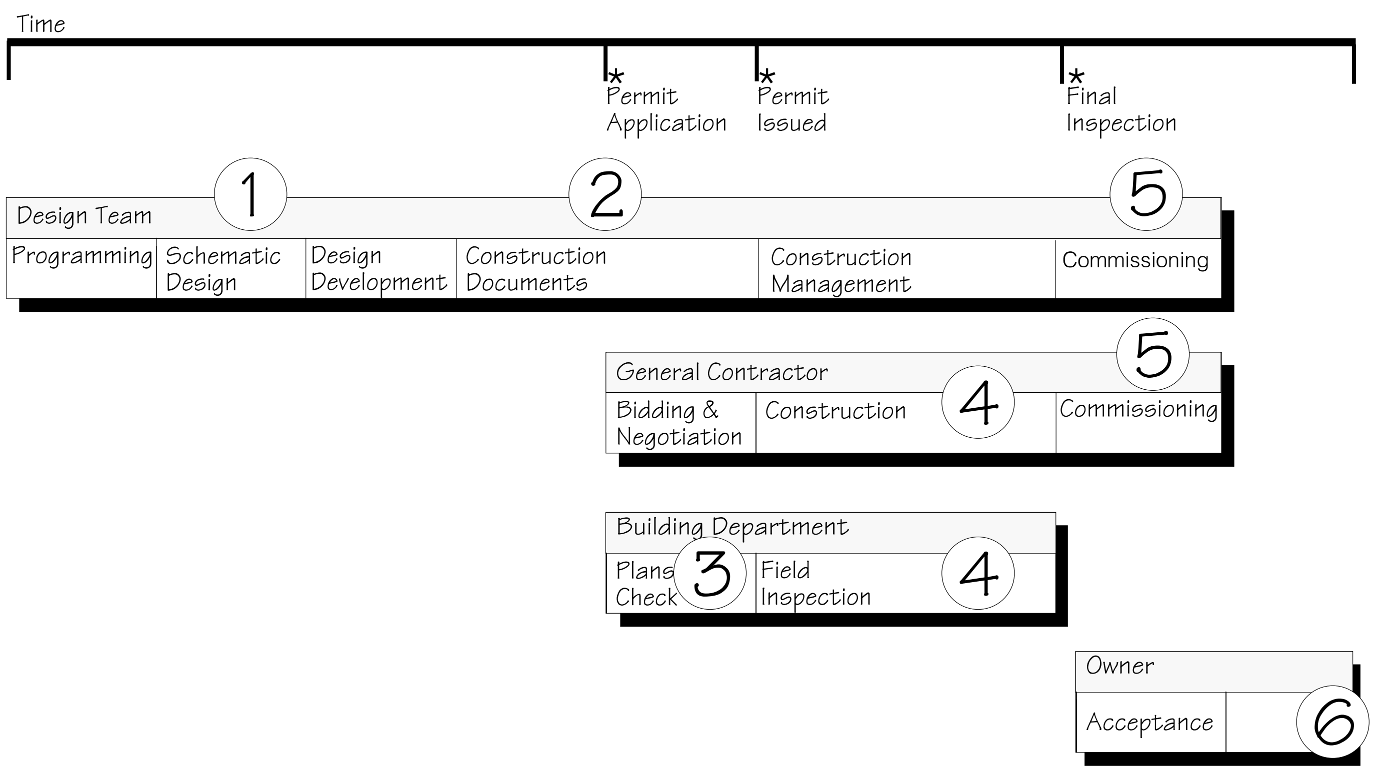
RESPONSIBILITIES AT EACH PHASE



To achieve the goal of cost effective energy savings, the 90.1 Code must be considered at all phases of the design and construction process: (see Figure 100C).

1. At the design phase, architects, engineers, and designers must understand both the requirements and the underlying intent of the 90.1 Code if they are to design buildings that are inherently energy efficient and cost effective. Coordination of building, HVAC, and lighting systems provides additional opportunities for energy efficiency.
2. At permit application, the design team must make sure that the plans contain all the information that the building official will need to verify that the building satisfies the requirements. Compliance forms and worksheets are provided in this manual to make sure that all the information is included. Blank forms are included at the end of the manual and sample filled out forms are included in the Case Study sub-section of each technical chapter.
3. During plan check, the building department plans examiner must verify that the building satisfies the requirements of the 90.1 Code and that the plans (not just the forms) contain the information to be verified during field inspections.

Figure 100C The Building Design and Construction Process



4. During construction, the contractor must carefully follow the approved plans and specifications and the building department field inspector(s) must verify that the building is constructed according to the plans and specifications.
5. After completion of construction, the contractor and/or the design team must properly commission the building and its systems and provide information and/or training to the building operators on maintenance and operation of the building and its equipment.
6. After occupancy, the building and its systems must be correctly operated and properly maintained. In addition, building users must be advised of their opportunities and responsibilities for saving energy (turn off lights when possible, etc.).

COORDINATION AND COMMUNICATION

Effective compliance and enforcement requires coordination and communication between the architects, engineers, lighting and HVAC designers, permit applicant, contractors, plans examiner, and the field inspector[6]. This manual recommends procedures to improve communications and, therefore, compliance with the code.

The building design and construction industry, as well as building departments, are organized around engineering disciplines.[7] The design of the electrical and lighting system is typically the responsibility of the lighting designer, electrical engineer, or electrical contractor. This person is responsible for designing a system that meets code, producing the plans and specifications, and for completing the compliance forms and worksheets. In larger building departments, an electrical plans examiner will review the electrical plans, specifications, and compliance documents, and an electrical field inspector will verify the correct installation of the systems in the field. This same division of responsibility is typical for the mechanical systems: the mechanical engineer or contractor does the design, prepares the drawings, and completes the forms; the mechanical plans examiner reviews his/her work; and the mechanical field inspector verifies correct construction in the field. For the building envelope, the architect typically does the design and completes the forms, the building official reviews the work, and the building field inspector verifies construction in the field.

Unless the whole building performance method of Section 102 is used, the compliance and enforcement process can be completed separately for each discipline. This enables each discipline to complete its work independently of the others. To facilitate this process, compliance forms have been subdivided by discipline. These include standard worksheets for calculations and a summary form with checklist. Within a particular discipline, the recommended steps are described as follows:

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6 For small projects, an architect or engineer may not be involved and the contractor may be the permit applicant.

7 Smaller building departments may not have this type of specialization.

1. The permit applicant:

    a. Provides information on the plans and/or specifications to enable the building official to verify that the building satisfies the code requirements. It is important that the necessary information be included on the plans since these will be the official record of the permit and the field inspector will generally not have a copy of the worksheets or compliance forms. The design professional may be asked to certify that the plans comply with the code.

    b. Performs the necessary calculations to show that the building meets the code. These calculations are documented on the drawings or on the worksheets provided in this manual and supported when necessary with data from national rating organizations or product and/or equipment manufacturers.

    c. Completes the summary form. This document is a listing of each of the major requirements of the code. The summary form includes information from the worksheets and references to the plans where the plans examiner can verify that the building meets the code.

2. The plans examiner:

    a. Reviews the plans and supporting material to verify that they contain the necessary information for a plan check.

    b. Checks the calculations and data contained on the worksheets.

    c. Indicates by checking a box on the summary form that the compliance documentation is acceptable.

    d. Makes notes for the field inspector about which items require special attention.

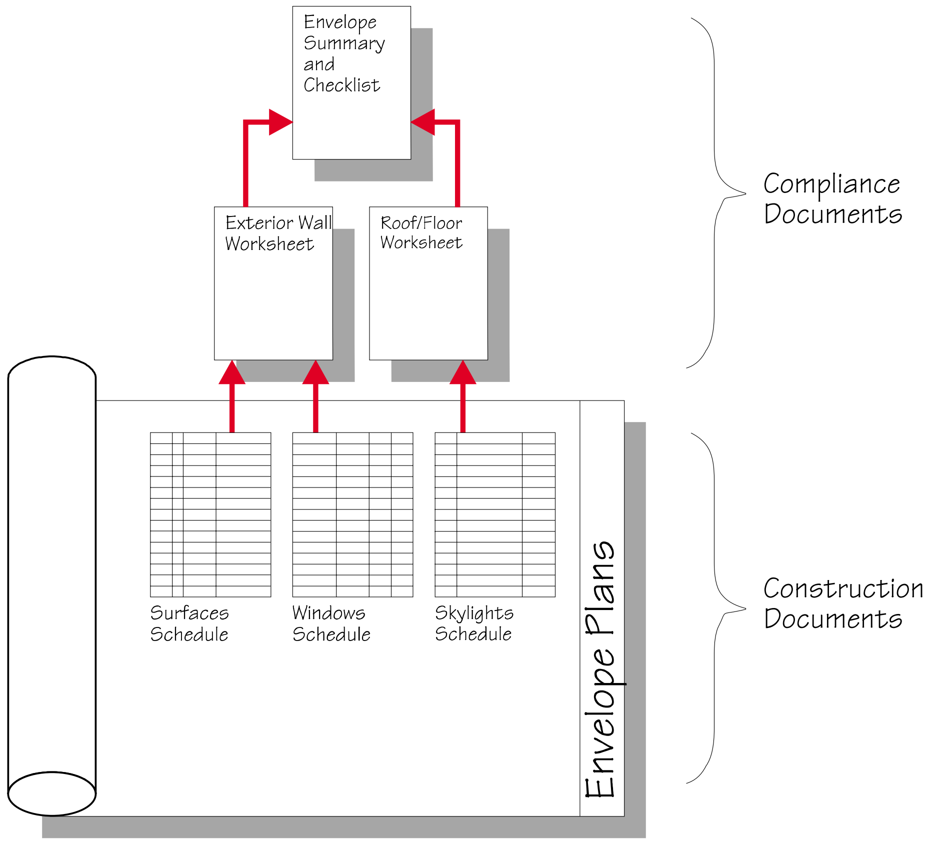
3. The field inspector:

    a. Verifies that the building is constructed according to the plans.

    b. Checks the appropriate items on the summary form at each relevant inspection.

The documentation required to implement these procedures is shown in Figure 100D. The same summary form is used by the permit applicant, the plans examiner, and the field inspector. This way, the permit applicant can call the plans examiner's attention to the relevant drawing sheets and other information, and the plans examiner can call the field inspector's attention to items that may require special attention in the field. The compliance forms and worksheets encourage communication and coordination within each discipline.

Figure 100D Documentation Required for Enforcement and Compliance – Building Envelope



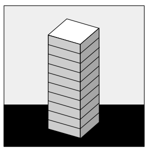
The summary forms and worksheets that are provided with this manual are intended to ease the process of complying with the code, not become an additional burden.

1. They help the permit applicant and designer know what information needs to be included on the plans.
2. They provide a structure and order for the necessary calculations. This benefits both the permit applicant (or documentation author) and the plans examiner as information is always presented in a consistent format.
3. They provide a roadmap showing the plans examiner where to look for the necessary information on the plans and specifications.
4. They provide a checklist for the plans examiner to help structure the plan check process.
5. They promote communication between the plans examiner and the field inspector.
6. They provide a checklist for the field inspector.

Case Studies

This manual uses two real buildings as case studies to illustrate points about the 90.1 Code. Detailed plans and descriptions of these buildings are contained in Appendix B. Following is a more general description of each one:

OFFICE BUILDING

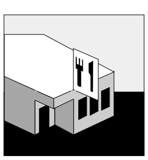


This is a small office building, typically constructed by businesses for their own use. It is one story with approximately 16,500 ft^2 of gross floor area, located in the Chattanooga, Tennessee. A complete set of plans and specifications are generally submitted to the building department when the permit application is filed. While the building type and size are typical, the energy efficiency features are exceptional and go far beyond code minimums.

- Daylighting is provided throughout the space through a combination of skylights and windows. The skylights have automatically controlled light louvers that maintain just the right amount of light. Splayed light wells reduce glare and help distribute the light.
- Electric lighting uses high efficiency dimming electronic ballasts and high efficiency fluorescent lamps. All electric lighting is controlled by an integrated system of occupancy sensors and photocells.
- Overhangs are provided on all sides of the building to shade the windows, especially during hotter summer conditions when the sun is higher in the sky.
- Fixed pitch, interior blinds are provided with perforations to diffuse the light from the windows and bounce it off the ceiling.
- The window glazing on each facade of the building is custom selected to provide the optimum balance of solar gains and daylighting. Three different materials are used: the most transparent glazing on the north; the least transparent on the west; and, a medium transmissive glazing on the east and south.
- A dual-duct, dual fan, variable air volume heating, ventilating, and air-conditioning system serves the building. This system provides comfort conditions to all areas of the building and minimizes energy use.
- Air volume is controlled by electronically controlled variable speed motors.
- Heating is provided by a high efficiency gas furnace.
- Cooling is provided by roof-top mounted packaged equipment. The equipment has three compressors (one variable speed) and heat rejection is provided by a cooling tower.
- An energy management system provides integrated control of the lighting, daylighting, and HVAC systems.

Completed sets of compliance forms for this case study building are provided in the case study section of Chapters 401, 402, 403, and 404.

RESTAURANT



This is a one story building of approximately 9,250 ft^2. It is typical of many medium-sized restaurants constructed in shopping malls and in strip commercial areas. The entrance lobby is on one end of the building and the service entrance is at the other. An entrance foyer, waiting area, toilets, and vestibule are located at the customer entrance end of the building. A walk-in cooler, dry storage room, kitchen, service area, dishwashing areas, managers office, cashier's office, and employee dressing area are located at the other end of the building. Six dining areas are located along the side walls of the building and this is where all the glazing is located. Windows are continuous along the dining areas with glass extending from a sill height of about 2 ft to the soffit. The windows are shaded by overhangs and canvas awnings. Five additional dining areas are located on the interior of the building along with a lounge.

The HVAC system consists of five rooftop mounted systems. Each consists of a direct expansion air conditioner and a gas furnace. The lighting system consists of fluorescent lensed troffers in the kitchen and service areas. A combination of incandescent down lights and track lights are used in the public areas.

This case study building is described in the Case Study section of Chapters 401, 402, 403, and 404 and is intended for use as a class exercise.